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Physical and Technological Characters of Milled Rice as Affected by Storage Periods, Treating with Phosphine and Oil Neem and Packages Types

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ABSTRACT

A laboratory experiments was conducted under the laboratory conditions of the Experimental Station of Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt, from 25th December, 2013 to 25th June, 2014. The aim of this study was to evaluate the effect of phosphine (as a chemical insecticide) and oil neem (as natural plant oil) rates and type of packages on physical and technological characters of milled rice Sakha 101 cultivar also under the environmental conditions of Dakahlia Governorate, Egypt, during different storage periods (2, 4 and 6 months from beginning of storage). The most important results can be summarized as follows:

The numbers of insects and yellow grains significantly increased due to increasing storage periods. The highest amylose and grain shape percentages were resulted from storage milled rice grains up to 2 months. The highest grain length after cooking and gelatinization temperature "GT" of milled rice were resulted from storage milled rice grains up to 6 months.

The best results of physical and technological characters of milled rice obtained when treating with phosphine at the rate of 6 balls/ton, followed treating with phosphine at the rate of 4 balls/ton, then treating with neem oil at the rate of 9 % and phosphine at the rate of 2 balls/ton.

The best results of physical and technological characters of milled rice resulted from samples of milled rice grains stored in gunny packages, followed stored in normal packages (twisting plastic), and then stored in light cloth packages.

It can be recommended that treating milled rice with phosphine insecticide at the rate of 4 - 6 balls/ton or neem oil at the rate of 9 % before storage in gunny or normal (twisting plastic) packages under the environmental conditions of the experiment in Mansoura, Egypt.

Keywords: Rice, Milled rice, Chemical insecticides, Phosphine, Neem oil, Packages types, Physical and technological characters.

INTRODUCTION

Rice (*Oryza sativa* L.) cultivation is the principal activity and source of income for millions of households around the globe and several countries of Asia and Africa. Rice is the most important summer cereal crop of traditional rice growing areas of Egypt and is among the major export commodities. Even though the area planted with rice is about 640100 hectare, which produced about 6 100 000 tons of paddy rice in 2013 season. Also, in Iraq, the total cultivated area of rice reached about 95808 hectare and the total production exceeded 451 849 tons (**FAO, 2015**).

Deterioration of stored grains is influenced by physical (temperature and humidity), biological (microflora, arthropod and vertebrate) and technical processes (storage conditions, methods and duration). During storage the rice grain may be damaged by insect pests, rodents, domestic animals, birds and storage fungi. More than 2000 species of field and storage pests annually destroy approximately one third of the world food production (**Talukder and Howse, 1994**). Losses due to stored grain pests (including insects, molds and toxins produced by fungi) may exceed 43 % of potential production per year in developing countries mainly due to improper management (**Ahmed et al. 1990**). The high post-harvest losses of grains ranging between 35 and 46% are attributed to the adverse weather conditions that favour growth of a number of insect pest and mites harmful to stored products, which reducing the quantity and/or quality of the stored products (**Evans, 1987**).

Altered susceptibility or resistance of various populations of harmful insects is the most restricting factor in chemical control as it may lead to excessive use of insecticides and to detrimental economic and ecological effects, plus a negative impact on human health (**Subramanyam and Hagstrum, 1996**). Fumigation with phosphine (PH_3, hydrogen phosphide) has the potential to disinfest stored grain. Phosphine fumigation offers a cost-effective method of treating grain so that insects are controlled. **Winks (1984)** concluded that the recommended strategy for phosphine fumigations is to maintain a lethal concentration until the most resistant stages mature into less resistant forms. **Chaudhry (2000)** found that the main method used for controlling insect infestations in stored commodities was fumigating with phosphine (PH_3) gas. In fact, the ease of use and residue-safe nature of phosphine has increased dependence upon the fumigant. **Collins et al. (2005)** reported that phosphine is relatively easy to use, versatile, cheap, and accepted internationally as a low-residue treatment. Although a number of alternative fumigants are being developed for stored grain, for example, carbonyl sulphide, hydrogen cyanide and ethyl formate none of these can match the combined properties of phosphine. **Lorini *et al.* (2011)** concluded that the release of gas in phosphinyl starts soon after the availability of the tablets on the environment, increasing the concentration over time until complete dissolution of the tablet steaming.

Control of stored product insects relies heavily on the use of synthetic insecticides and fumigants led to problems such as environmental disturbances, increasing costs of application, pest resurgence, pest resistance to pesticides and lethal effects on non-target organisms, toxic residues in food grains in addition to direct toxicity to users (**Isman, 2006**). Further, due to the problem of resistance to insecticides, there is an urgent need for safer alternatives to conventional chemical insecticides particularly from natural sources, for the protection of grain against insect infestation. In view of all the aspects in grain protection and these problems have highlighted the urgent need to develop newer ecofriendly safer and effective stored-product insecticide such as plant oils. Essential plant oils are the by-products of plant metabolism and are commonly referred to as volatile plant secondary metabolites. The characteristics of essential plant oils provide various functions for the plants including (i) attracting or repelling insects, (ii) protecting themselves from heat or cold; and (iii) utilizing chemical constituents in the oil as defense materials (**Bakkali et al., 2008**). Neem oil is used to manufacture neem oil insecticide because it contains azadirachtin which effects over 600 species of pests including insects, nematodes, fungi and viruses and is completely safe to non target organisms like beneficial predators, honey bees, pollinators, fish, birds, cattle and human beings. Azadirachtin of neem oil is a famous natural anti-feedent, growth regulator and ovi-positional repellent for insects, as a major active ingredient which make it a perfect alternative to chemical pesticides. Neem products activity persists on plants about four to seven days after its application, which means it presents fast degradation and, consequently, a low intoxication risk to mammalians and birds (**Quintela and Pinheiro 2009**). It has many useful compounds, including azadirachtin and tetranotriterpenoid limonoid, the active ingredient in many neem-based insecticides (**Mordue and Blackwell, 1993**). All parts of neem especially seed oil possessed antifeedant, repellant, growth disrupting and larvicidal properties against a large number of pests (**Mathur, 2013**).

Therefore, this investigation was established to study the effect of phosphine (as a chemical insecticide), oil neem (as a plant oil) and type of packages on physical and technological characters of milled rice Sakha 101 cultivar during different storage periods (2, 4 and 6 months from beginning of storage) under the environmental conditions of Dakahlia Governorate, Egypt.

MATERIALS AND METHODS

A laboratory experiments was conducted under the laboratory conditions of the Experimental Station of Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt, from 25th December, 2013 to 25th June, 2014. The aim of this study was to evaluate the effect of phosphine (as a chemical insecticide) and oil neem (as natural plant oil) rates and type of packages on physical and technological characters of milled rice Sakha 101 cultivar also under the environmental conditions of Dakahlia Governorate, Egypt, during different storage periods (2, 4 and 6 months from beginning of storage).

The treatments were arranged in factorial experiment in randomized complete block design (RCBD) with four replications.

- The first factor was seven milled rice grain treatments as follows:

1. Control treatment (without any treatment).
2. Treating milled rice grains with phosphine at the rate of 2 tablets/ton.
3. Treating milled rice grains with phosphine at the rate of 4 tablets/ton.
4. Treating milled rice grains with phosphine at the rate of 6 tablets/ton.
5. Treating milled rice grains with neem oil at the rate of 3%.
6. Treating milled rice grains with neem oil at the rate of 6%.
7. Treating milled rice grains with neem oil at the rate of 9%.

- The second factor was four types of packages as follows:

1. Stored milled rice grains in polyethylene (nylon) package.
2. Stored milled rice grains in light cloth package.
3. Stored milled rice grains in normal package (twisting plastic).
4. Stored milled rice grains in gunny package.

In all studied treatments, 3 kg of milled rice grains in each replicate were stored in various packages as formerly mentioned. The studied milled rice Sakha 101 cultivar was obtained also from the Experimental Farm of Sakha Agricultural Research Station, Kafrelsheikh Governorate, Agricultural Research Center (ARC), Egypt.

The phosphine insecticide (aluminium phosphide) and neem oil under study were produced by T. Stanes & Company Limited, India and obtained from Gaara Establishment for Import and Export Co.

Phosphine tablets which were used in the experiment were from an Indian origin and the rate of the active material was 57% like all other international origin. It is important to mention that the activity of phosphine tablets will take action when it is subject to air. In phosphine treatment, paddy or milled rice has been put in plastic containers with sealing (drums) and then treated with various rates of phosphine for three days and then start of storage.

The neem oil was dissolved with acetone firstly, and then diluted with water to the studied rates. Paddy or milled rice grains were sprayed and well mixed with plant oils with various rates, and then beginning storage.

STUDIED CHARACTERS

A- Physical characters:

After each storage period (2, 4 and 6 months from beginning storage), 1 kg of milled rice of each treatment was taken to estimate the following characters:

1. Number of insects.
2. Number of yellow grains.

B- Technological characters:

After each storage period (2, 4 and 6 months from beginning storage), 1 kg of milled rice of each treatment was taken to estimate the following characters in Grain Quality Laboratory in Rice Research and Training Center, Sakha, Kafrelsheikh Governorate, Agricultural Research Center, Egypt:

1- Amylose percentage: It was estimated according to **Juliano (1971)**.

2. Grain shape (%):

The shape of milled rice grain before cooking was determined by the length (L): width (W) ratio following the standard evaluation system for rice (**IRRI, 1996**).

3. Grain length after cooking (mm):

Grain length after cooking is a measure of milled rice grain in its greatest dimension in mm. It was measured from the base to the top of the grain. Grain length was classified using the Standard Evaluation System for rice **(IRRI 1996**).

4. Gelatinization temperature (GT) :

Six whole milled grains of rice from each treatment were spaced evenly in small transparent plastic boxes, containing 10 ml of potassium hydroxide solution 1.70%. The boxes are covered and left undisturbed for 23 hours in an incubator maintained at 30 ºC. Such alkali spreading and clearing of starchy endosperm represented the GT, which was visually rated on a 7- point numerical scale adopted by **Little *et al.* (1958).**

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the randomized complete block design (RCBD) as published by **Gomez and Gomez (1984)** by using means of "MSTAT-C" computer software package. New least significant of difference (NLSD) method was also used to test the differences between treatment means at 5% level of probability as described by **Waller and Duncan (1969)**.

RESULTS AND DISCUSSION

1- Effect of storage periods:

Increasing storage periods of milled rice grains from 2 to 4 and 6 months significantly affected physical characters of milled rice (number of insects and yellow grains) as shown in Table 1 and technological characters of milled rice (amylose, grain shape percentages, grain length after cooking and gelatinization temperature "GT") as shown in Table 2.

The numbers of insects and yellow grains in milled rice grains was significantly increased due to increasing storage periods from 2 to 4 and 6 months from beginning of storage. Whereas, the highest amylose and grain shape percentages were resulted from storage milled rice grains up to 2 months, and followed by storage milled rice grains up to 4 months and lastly storage milled rice grains up to 6 months. However, the highest grain length after cooking and gelatinization temperature "GT" of milled rice were resulted from storage milled rice grains up to 6 months, and followed by storage milled rice grains up to 4 months and then storage milled rice grains up to 2 months. These results may be owing to unsuitable conditions for storage, instability of the temperature and humidity during storage periods, moreover faded the effect of treating milled rice grains with chemical insecticides (phosphine) or plant oils (oil neem) before storage.

2- Effect of milled rice grains treatment:

Milled rice grains treatments (untreated grains, treating with phosphine at the rates of 2, 4 and 6 balls/ton and oil neem at the rates of 3, 6 and 9%) significantly affected physical characters of milled rice (number of insects and yellow grains) and technological characters of milled rice (amylose, grain shape percentages, grain length after cooking and gelatinization temperature "GT") as shown in Tables 3 and 4.

The highest numbers of insects and yellow grains that observed in milled rice were resulted from milled rice grains stored without any treatment (control treatment). Whereas, the lowest numbers of insects and yellow grains that noticed in milled rice were produced from treating milled rice grains with phosphine at the rate of 6 balls/ton (Table 3). The second best grains treatment was treating with phosphine at the rate of 4 balls/ton and then treating with neem oil at the rate of 9 %.

The highest values of technological characters of milled rice (amylose, grain shape percentages, grain length after cooking and gelatinization temperature "GT") were resulted from treating milled rice grains before storage with phosphine at the rate of 6 balls/ton (Table 4). The order of other treatment was as follows; phosphine at the rate of 4 balls/ton > neem oil at the rate of 9 % > neem oil at the rate of 6 % > phosphine at the rate of 2 balls/ton > neem oil at the rate of 3 % > untreated (control).

These results probably due to efficiency of phosphine at these concentrations in prevent or reduction damaged grains, grains weight loss percentages and change of chemical composition as result of its poison effect (**Winks, 1984 ; Chaudhry, 2000 and Collins et al., 2005**), prevented the insects piercing and entering into grains. In addition, the decline in numbers of yellow grains in milled rice grains by treating with neem oil at the rate 9% probably due to efficiency of neem oil at these concentrations in prevent or reduction damaged grains, grains weight loss percentages and maintenance chemical constituents of milled rice grains result of its antifeedant and repellence effects (**Mathur, 2013**), prevented the insects piercing and entering into grains and increasing insect growth inhibition.

3- Effect of packages types:

Studied packages types that used in storage milled rice grains (polyethylene (nylon), light cloth, normal (twisting plastic) and gunny) significantly affected physical characters of milled rice (number of insects and yellow grains) and technological characters of milled rice (grain shape percentages, grain length after cooking and gelatinization temperature "GT") as shown in Tables 3 and 4.

The lowest numbers of insects and yellow grains that observed in milled rice were recorded in the samples of milled rice grains stored in gunny packages, followed stored in normal packages (twisting plastic), and then stored in light cloth packages. While, the highest numbers of insects and yellow grains produced from the samples of milled rice grains stored in polyethylene (nylon) packages.

The highest of technological characters of milled rice (amylose, grain shape percentages, grain length after cooking and gelatinization temperature "GT") were recorded in the samples of milled rice grains stored in gunny packages, followed stored in normal packages (twisting plastic), then stored in light cloth packages and lastly stored in polyethylene (nylon) packages.

These results probably due to good aeration, which keeping temperature and relative humidity in suitable levels, consequently reduced the growth and spread of insects and the availability of good conditions for storage.

4- Effect of the interactions:

Regarding the effect of interactions, there are many significant effects of the interactions on the studied characters. We present only the third interaction among studied factors *i.e.* storage periods, milled rice grain treatments and packages types, which exhibited significant effect on number of insects and grain length after cooking. Storage milled rice grains in gunny packages and treating with phosphine at the rate of 6 balls/ton or 4 balls/ton or storage in normal (twisting plastic) packages and treating with phosphine at the rate of 6 balls/ton did not recorded any insects after 2 months of storage as graphically illustrated in Fig. 1. Storage milled rice grains in gunny packages and treating with phosphine at the rate of 6 balls/ton after 6 months of storage recorded the highest values of grain length after cooking of milled rice as graphically illustrated in Fig. 2.

CONCLUSION

This study recommended that treating milled rice with phosphine insecticide at the rate of 4 - 6 balls/ton or neem oil at the rate of 9 % before storage in gunny or normal (twisting plastic) packages under the environmental conditions of the experiment in Mansoura, Dakahlia Governorate, Egypt.

REFERENCES

Ahmed, M. ; A. Shoukat and A. Ahmed (1990). Physical quality characteristics of wheat at farm gate procurement centers in Sindh and Punjab. Sarhad J. Agric., 6: 589-596.

Bakkali, F. ; S. Averbeck ; D. Averbeck and M. Idaomar (2008). Biological effects of essential oils: A review. J. of Food Chem. and Toxico., 46: 446-475. http://dx.doi.org/10.1016/ j.fct.2007.09.106.

Chaudhry, M.Q. (2000). Phosphine resistance: a growing threat to an ideal fumigant. Pesticide Outlook, June 2000, 88–91 (C.F. Computer Search).

Collins, P.J. ; G.J. Daglish ; H. Pavic and R.A. Kopittke (2005). Response of mixed-age cultures of phosphine-resistant and susceptible strains of lesser grain borer, *Rhyzopertha dominica*, to phosphine at a range of concentrations and exposure periods. J. of Stored Products Res., 41: 373–385.

Evans, D.E. (1987). Stored products. In: Burn, A.J., Coaker, T.H., Jepson, P.C. (Eds.), Integrated Pest Management. Academic Press, London, UK, pp. 425–461.

FAO (2015). FAO Statistics Division 2015, April, 2015.

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedures for Agricultural Research. 2nd Ed., Jhon Wiley and Sons Inc., New York, pp: 95-109.

IRRI (International Rice Research Institute) (1996). Standard evaluation System for Rice. International Rice Research Institute (IRRI), P.O. Box 933, 1099 Manila, Philippines.

Isman M.B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Ann. Rev. Entomol., 51: 45-66.

Juliano, B.O. (1971). A simplified assay for milled rice amylase cereal. Sci. Today, 16: 334-360 (C.F. Computer Search).

Little, R. ; B. Hilder and H. Dawson (1958). Differential effect of dilute alkali on 25 cultivars of milled white rice. Cereal Chem., 35: 111-126.

Lorini, I. ; F.C. Krzyzanowski ; J.B. Franca-Neto and A.A. Henning (2011). Monitoring the release of gas by PH_3 past islands of phosphine used to purge seed. Informativo Abrates., 21(3): 57-60 (C.F. Computer Search).

Mathur, S. (2013). Biopesticidal activity of *Azadirachta indica* A Juss. Res. J. Pharm. Biol. Chem. Sci., 4(2): 1131-1136.

Mordue, A.J. and A. Blackwell (1993). Azadirachtin: an update. J. Insect Physiol., 39: 903–924.

Quintela, E.D. and P.V. Pinheiro (2009). Redução da oviposição de Bemisia tabaci (Genn.) biótipo B (Hemiptera: Aleyrodidae) em folhas de feijoeiro tratadas com extratos botânicos. Bioassay, Piracicaba, 4(8): 1-10 (C.F. Computer Search).

Subramanyam, B. and D.W. Hagstrum (1996). Resistance measurement and management. In: Subramanyam, B., Hagstrum, D.W. (Eds.), Integrated Management of Insects in Stored Products. Marcel Dekker, New York, Basel, Hong Kong, pp: 331–397.

Talukder F.A. and P.E. Howse (1994). Efficacy of pirthaj (*Aphanamixis polystachy*) seed extract against stored product pests stored product protecting. Proceeding of 16 International working inferences from 17-23 Aport comberra Australia, pp. 848-852.

Waller, R.A. and D.B. Duncan (1969). A bays rule for the symmetric multiple comparison problem. J. Amer. Assoc., 64: 1484-1503.

Winks, R.G. (1984). The toxicity of phosphine to adults of *Tribolium castaneum* (Herbst.): time as a dosage factor. J. of Stored Products Res., 20: 45-56.

Table 1: Number of insects and yellow grains as affected by storage periods, treating milled rice grains with phosphine insecticide and neem oil at various rates and packages types.

Characters / Treatments	Number of insects	Number of yellow grains
A- Storage periods:		
2 Months	1.35	1.20
4 Months	3.95	2.26
6 Months	7.38	3.09
F. test	*	*
NLSD at 5 %	0.27	0.15
B- Grains treatments:		
Untreated (control)	10.27	4.47
Phosphine at the rate of 2 balls/ton	4.20	2.06
Phosphine at the rate of 4 balls/ton	1.31	1.08
Phosphine at the rate of 6 balls/ton	0.66	0.64
Neem oil at the rate of 3 %	7.08	3.27
Neem oil at the rate of 6 %	4.06	2.35
Neem oil at the rate of 9 %	2.02	1.43
F. test	*	*
NLSD at 5 %	0.41	0.24
C- Packages types:		
Polyethylene (nylon)	5.48	2.83
Light cloth	4.46	2.34
Normal (twisting plastic)	3.79	1.96
Gunny	3.17	1.61
F. test	*	*
NLSD at 5 %	0.31	0.18
D- Interaction:		
A × B	*	*
A × C	NS	*
B × C	*	*
A × B × C	*	NS

Table 2: Amylose percentage, grain shape (%), grain length after cooking (mm) and Gelatinization temperature (GT) as affected by storage periods, treating milled rice grains with phosphine insecticide and neem oil at various rates and packages types.

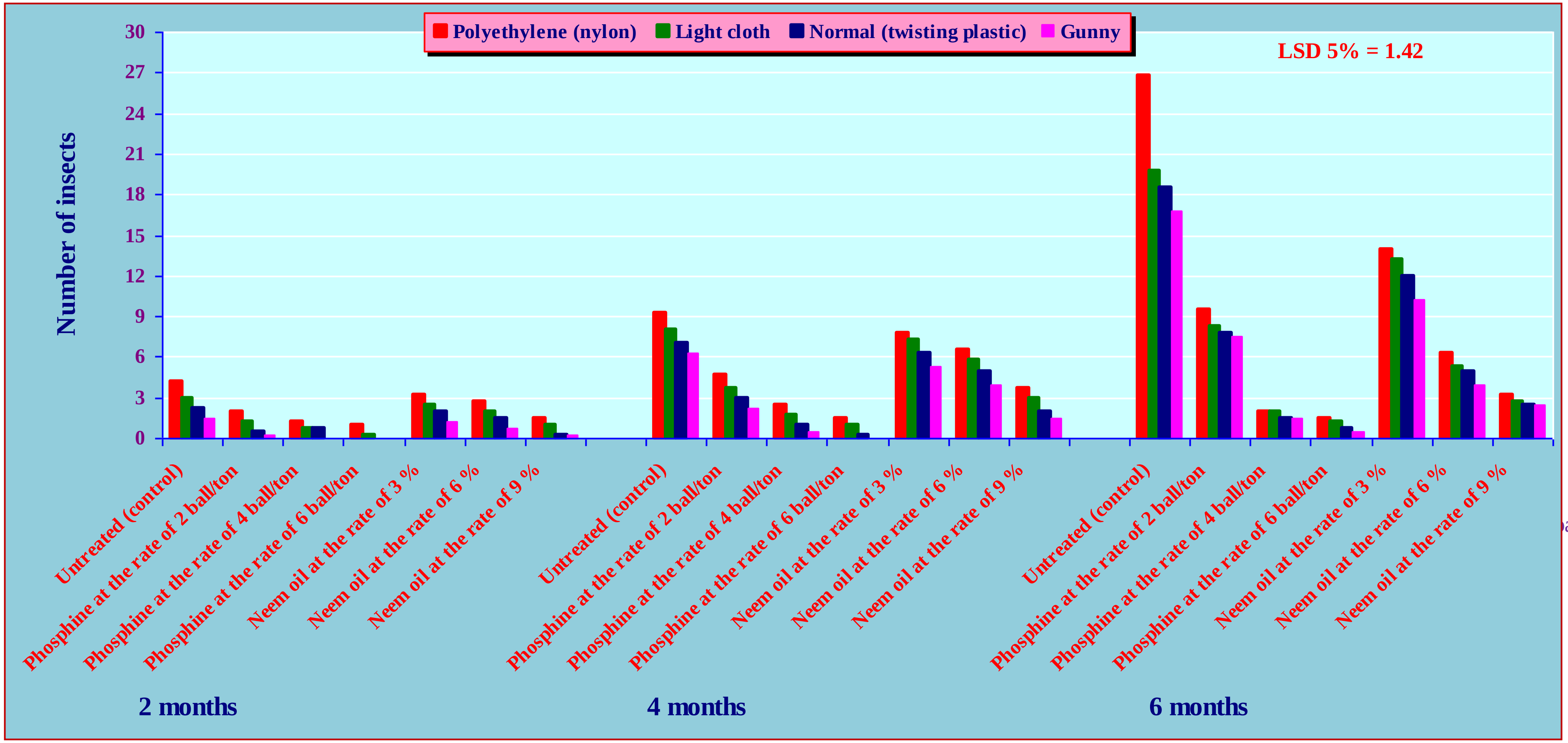
Characters / Treatments	Amylose percentage	Grain shape (%)	Grain length after cooking (mm)	GT
A- Storage periods:				
2 Months	19.48	2.02	5.73	5.42
4 Months	19.31	1.98	6.41	5.43
6 Months	19.00	1.95	6.81	5.67
F. test	*	*	*	*
NLSD at 5 %	0.17	0.03	0.02	0.11
B- Grains treatments:				
Untreated (control)	18.69	1.91	5.54	5.22
Phosphine at the rate of 2 balls/ton	19.20	1.97	6.17	5.43
Phosphine at the rate of 4 balls/ton	19.61	2.01	6.65	5.62
Phosphine at the rate of 6 balls/ton	19.69	2.09	7.17	5.68
Neem oil at the rate of 3 %	18.57	1.96	5.89	5.54
Neem oil at the rate of 6 %	19.47	1.97	6.32	5.52
Neem oil at the rate of 9 %	19.59	1.98	6.46	5.54
F. test	*	*	*	*
NLSD at 5 %	0.12	0.04	0.03	0.18
C- Packages types:				
Polyethylene (nylon)	19.08	1.95	6.19	5.23
Light cloth	19.25	1.98	6.27	5.24
Normal (twisting plastic)	19.34	1.99	6.35	5.44
Gunny	19.37	2.01	6.45	6.13
F. test	NS	*	*	*
NLSD at 5 %	-	0.03	0.02	0.14
A × B	NS	NS	*	*
A × C	NS	NS	*	NS
B × C	NS	NS	*	*
A × B × C	NS	NS	*	NS

Table 3: Number of insects and yellow grains as affected by treating milled rice grains with phosphine insecticide and neem oil at various rates and packages types after 2, 4 and 6 months of storage.

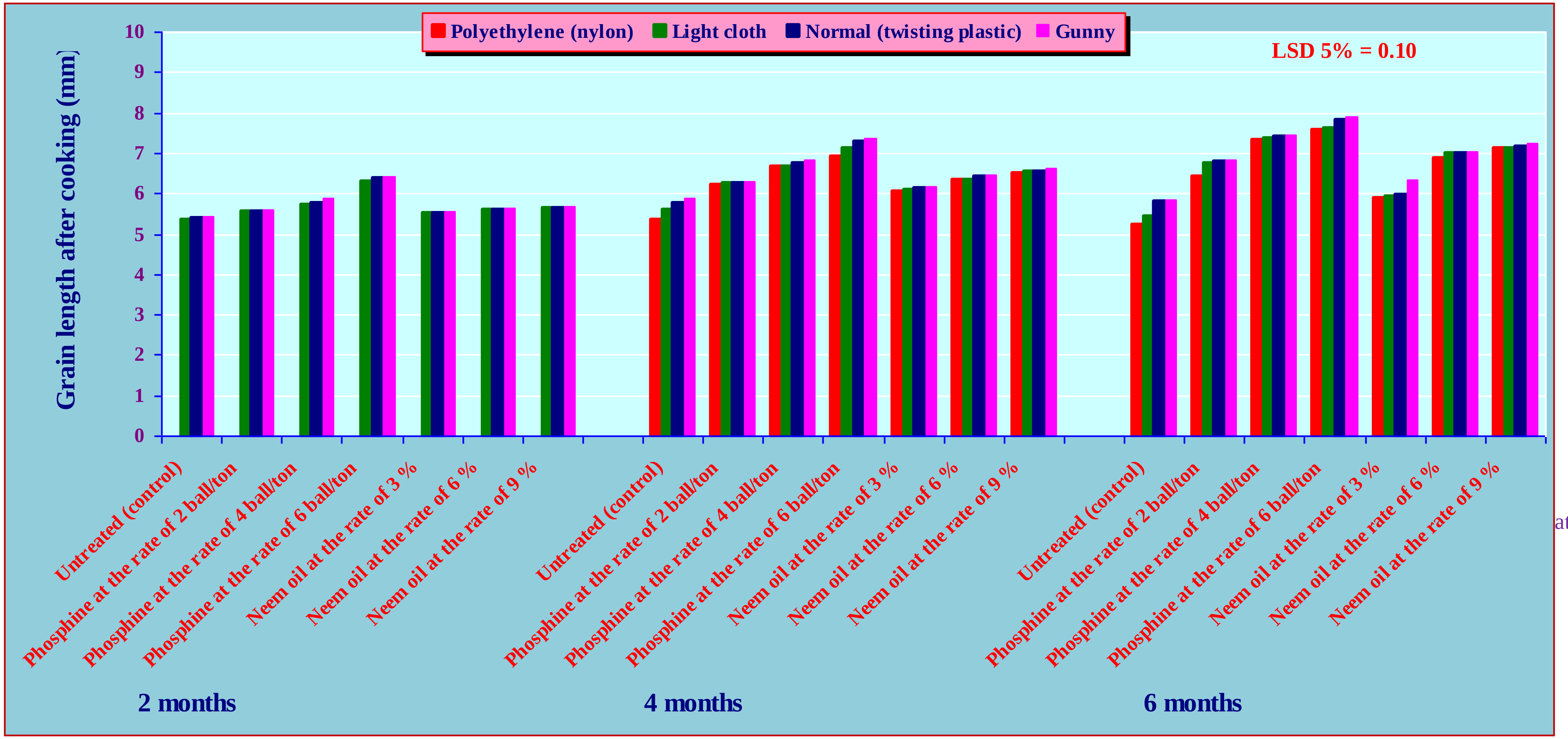
Characters / Treatments	Number of insects			Number of yellow grains		
	2 Months	**4 Months**	**6 Months**	**2 Months**	**4 Months**	**6 Months**
A- Grains treatments:						
Untreated (control)	2.75	7.62	20.43	2.37	4.62	6.43
Phosphine at the rate of 2 balls/ton	0.93	3.43	8.25	1.18	1.81	3.18
Phosphine at the rate of 4 balls/ton	0.75	1.43	1.75	0.56	0.81	1.87
Phosphine at the rate of 6 balls/ton	0.31	0.68	1.00	0.25	0.56	1.12
Neem oil at the rate of 3 %	2.25	6.62	12.37	1.81	3.87	4.12
Neem oil at the rate of 6 %	1.75	5.31	5.12	1.50	2.87	2.68
Neem oil at the rate of 9 %	0.75	2.56	2.75	0.75	1.31	2.25
F. test	*	*	*	*	*	*
NLSD at 5 %	0.42	0.41	0.93	0.24	0.51	0.33
B- Packages types:						
Polyethylene (nylon)	2.28	5.14	9.03	1.85	3.17	3.46
Light cloth	1.53	4.35	7.50	1.35	2.50	3.17
Normal (twisting plastic)	1.03	3.50	6.85	0.96	1.92	3.00
Gunny	0.57	2.82	6.14	0.64	1.46	2.75
F. test	*	*	*	*	*	*
NLSD at 5 %	0.32	0.31	0.74	0.18	0.38	0.25
C- Interaction (A × B):	NS	NS	*	*	NS	*

Table 4: Amylose percentage, grain shape (%), grain length after cooking (mm) and Gelatinization temperature (GT) as affected by treating milled rice grains with phosphine insecticide and neem oil at various rates and packages types after 2, 4 and 6 months of storage.

Treatments	**Amylose percentage**			**Grain shape (%)**			**Grain length after cooking (mm)**			**GT**		
	2 Months	**4 Months**	**6 Months**	**2 Months**	**4 Months**	**6 Months**	**2 Months**	**4 Months**	**6 Months**	**2 Months**	**4 Months**	**6 Months**
A- Grains treatments:												
Untreated (control)	18.88	18.52	18.68	1.90	1.96	1.84	5.40	5.65	5.57	5.25	5.37	5.00
Phosphine at the rate of 2 balls/ton	19.41	19.55	18.65	2.00	1.97	1.96	5.58	6.25	6.69	5.43	5.43	5.50
Phosphine at the rate of 4 balls/ton	19.76	19.88	19.20	2.06	1.99	1.97	5.83	6.72	7.38	5.44	5.56	5.93
Phosphine at the rate of 6 balls/ton	19.78	19.92	19.37	2.20	2.03	2.04	6.45	7.20	7.88	5.56	5.62	6.00
Neem oil at the rate of 3 %	19.20	17.75	18.78	1.94	1.96	1.95	5.53	6.10	6.03	5.37	5.37	5.68
Neem oil at the rate of 6 %	19.59	19.75	19.07	1.98	1.97	1.96	5.62	6.39	6.96	5.42	5.31	5.81
Neem oil at the rate of 9 %	19.70	19.82	19.24	2.03	1.98	1.97	5.67	6.55	7.16	5.43	5.37	5.81
F. test	*	*	*	*	*	NS	*	*	*	NS	NS	*
NLSD at 5 %	0.08	0.18	0.12	0.02	0.02	-	0.03	0.07	0.02	-	-	0.32
B- Packages types:												
Polyethylene (nylon)	19.39	19.42	18.95	1.99	1.97	1.89	5.67	6.29	6.62	5.16	5.10	5.35
Light cloth	19.49	18.78	18.98	2.00	1.98	1.96	5.70	6.37	6.74	5.18	5.17	5.42
Normal (twisting plastic)	19.50	19.50	19.02	2.01	1.98	1.97	5.74	6.45	6.85	5.25	5.35	5.71
Gunny	19.52	19.56	19.04	2.06	1.99	2.00	5.80	6.53	7.02	6.07	6.10	6.21
F. test	*	NS	NS	*	NS	NS	*	*	*	*	*	*
NLSD at 5 %	0.06	-	-	0.02	-	-	0.02	0.06	0.02	0.22	0.24	0.26
C- Interaction (A × B):	*	NS	NS	*	NS	NS	*	*	*	*	NS	*


Polyethylene (nylon)
Light cloth
Normal (twisting plastic)
Gunny
LSD 5% = 1.42
Number of insects
30
27
24
21
18
15
12
9
6
3
0
Untreated (control)
Phosphine at the rate of 2 ball/ton
Phosphine at the rate of 4 ball/ton
Phosphine at the rate of 6 ball/ton
Neem oil at the rate of 3 %
Neem oil at the rate of 6 %
Neem oil at the rate of 9 %
2 months
4 months
6 months

packages


Polyethylene (nylon)
Light cloth
Normal (twisting plastic)
Gunny
LSD 5% = 0.10
Grain length after cooking (mm)
0
1
2
3
4
5
6
7
8
9
10
Untreated (control)
Phosphine at the rate of 2 ball/ton
Phosphine at the rate of 4 ball/ton
Phosphine at the rate of 6 ball/ton
Neem oil at the rate of 3 %
Neem oil at the rate of 6 %
Neem oil at the rate of 9 %
2 months
4 months
6 months

ates and